The Emergence of Cryptocurrency (Bitcoin) and How it is Valued "An Empirical Evidence"

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ABSTRACT

Cryptocurrency, a phenomenon that has flooded main stream media and gained the interests of all walks of life may they be academic, governmental or financial but what is it exactly, is it a currency to be used as a medium of exchange to buy and sell products and services, is it an asset that can be used as a store of value? Does it have any intrinsic value? Or is it a technological trend used as a speculative asset and will fade away with time.

In order to have a clearer understanding of cryptocurrency this thesis used the cryptocurrency with the largest market share BITCOIN. The data that was gathered did not only include when it started circulation and its price in the market but included all elements that are used in the mining process. From the data gathered two things were implemented. A cost of production model to identify the intrinsic value of mining for a BITCOIN and if it is worth the investment, after that an ARDL approach was used with long and short run modules and an error correction term, finally to support the findings reached a Granger Causality Test was used.

For the cost of production model the results proved that BITCOIN in its present form and network is not fundamentally used as a medium of exchange but rather a store of value. Most importantly it showed that the opportunity cost of buying BITCOINS was far more profitable than mining for it. For the ARDL approach the finding proved that some variables had a significant impact on market price while other variables had a negative yet statistically significant impact on market price.

Keywords: Cryptocurrency, Bitcoin, Cost of Production, ARDL

ÖZ

Cryptocurrency, bir fenomen olarak medyada hatırı sayılır bir yer tutmuş ve hayatın her kesiminden ilgi görmüştür, örneğin akademik, hükümetsel veya finansal, fakat tam olarak nedir, ürünlerin ve hizmetlerin satın alınması ve satılması için bir değişim aracı olarak kullanılacak bir para birimidir, değer deposu olarak kullanılabilen bir varlık mı? Herhangi bir içsel değeri var mı? Ya da teknolojik bir akım olarak kullanılan spekülatif bir varlıkmıdır ve zamanla kaybolacak mıdır.

Cryptocurrency hakkında daha net bir anlayışa sahip olmak için bu tez, en büyük pazar payına sahip olan kripto para birimini olan BITCOIN kullanmıştır. Toplanan veriler, sadece piyasaya sürüldüğünde ve piyasadaki fiyatını içermekle kalmayıp, madencilik sürecinde kullanılan tüm unsurları içermiştir.

Toplanan verilerden iki şey uygulanmıştır. Üretim modeli maliyeti kullanılarak BITCOIN madenciliğin içsel değerini ve yatırıma değerliliği belirlenmiştir, daha sonar ARDL yaklaşımı ile uzun ve kısa vade modellerine ve bir hata düzeltme terimi kullanılmıştır, nihayetinde elde edilen bulgular Granger Nedensellik Testi ile desteklenmiştir.

Üretim modeli maliyetinin sonuçları, BITCOIN'in mevcut hali bir değişim aracı olarak değil, bir değer deposu olarak kullanıldığını kanıtlamıştır. En önemlisi, BITCOINS satın almanın fırsat maliyetinin, madencilikten çok daha karlı olduğunu göstermiştir. ARDL yaklaşımının bulguları ise, bazı değişkenlerin piyasa fiyatı üzerindestatistiksel olarak anlamlı ve artırıcı bir etkiye sahip olduğunu, diğer değişkenlerin ise piyasa fiyatı üzerinde istatistiksel olarak anlamlı ve azaltıcı bir etkiye sahip olduğunu kanıtlamıştır.

Anahtar Kelimeler: Kripto para, Bitcoin, Üretim maliyeti, ARDL

DEDICATION

I dedicate this thesis in whole to my father Eng. Nassar Mahmoud Al-Madhoun. A man that always saw the positive in every negative and believed there is always an opportunity no matter how difficult the situation is. As he would always say:

"THE ONLY THING THAT IS IMPOSSIBLE IS IMPOSSIBILITY ITSELF"

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Chapter 1

INTRODUCTION

1.1 Brief Overview

Money, simply a medium used by individuals to exchange one commodity for another. This medium of exchange has evolved drastically since its inception. From its humble beginnings as a barter system in which one individual would exchange a commodity they had with another commodity that they wanted. This system as simple as it was had various setbacks, first you had to find a person that wanted what you had but at the same time had what you wanted which was surely time consuming, yet its biggest setback was how both parties valued their commodities. Over the centuries the medium evolved using livestock, wheat and grain, metal, leathers, gold, copper, silver, fiat money, credit-cards and finally where we are today on-line payments. Two fundamental factors where the base to how a medium of exchange evolved, its speed in completing any given transaction and most importantly trust (value) all parties had in the medium.

In the year 2008 a financial crisis hit the United States, which had a domino effect on the global financial markets and led to a recession that affected millions of people across the globe resulting in them losing their savings, benefits, jobs and houses. (Sapienza & Zingales, 2012) stated that the process in which the governments handled the crisis resulted in a lack of trust in the present financial system and how centralized it is.

On the 31st of October 2008 a white paper was published by an unknown person or group of people going by the name Satoshi Nakamoto “Bitcoin: A Peer-to-Peer Electronic Cash System” which circulated at an unprecedented rate. The paper introduced a new form of exchange Cryptocurrency “Bitcoin” which is simply a peer-to-peer form of electronic cash, meaning that two individuals can make any sort of transaction using this electronic currency directly, hence eliminating any middle party involved “Banks and financial institutions” this form of payment challenged the current transaction system which is regulated by governments and central banks (Weber, 2012).

By January 2009 enthusiasts in the area of cryptography and individuals that believed that there should be a decentralized currency started collecting Bitcoins “Miners” through a process called Mining. The mining process had a fundamental purpose which was to confirm that all transactions occurring in the Bitcoin system were accurate by implementing Block Chain Technology, after the transactions were verified they were placed into a block. Whenever a block was completed the miners would be compensated with Bitcoins “Block Reward”. In 2009 the block reward was 50 Bitcoins per block and that number decreased with time reaching 12.5 Bitcoins per block by 2008. The total amount of Bitcoins that will be circulating in the world will be 21,000,000 Bitcoins and it is estimated that the last bitcoin mined will be by the year 2140.

As of April 2018 there are approximately 17.021 million Bitcoins in circulation (figure 1 in appendix section) with an estimated net worth of 158.6 billion U.S dollars (Bitcoin Block Reward Halving Countdown, 2018). It is important to note that Bitcoin had literally no value what so ever till the 3rd quarter of 2010 and even then the market price was so insignificant that there was no real interest in it either by the financial market or the academic world. It wasn't till the 1st quarter of 2013 that people started noticing and paying interest to Bitcoin because of the noticeably large jump in its price from a 2-digit to a 3-digit figure. By the year 2017 Bitcoin reached a market price exceeding 19000 U.S dollars which placed it in the spotlight of Governments, Financial institutions and Academicians alike.

The huge leap from an initial 0.05 U.S. dollars in 2010 to over 19000 U.S. dollars in 2017 divided the financial and academic world into two groups "Figure 2 appendix section". The first group being pro Bitcoin and believing that the rise in its price is due to trust in a currency that cannot be corrupted and that it follows the patterns of supply and demand and an efficient market structure (Bartos,2015) whilst the other group believes that it is merely a bubble created by speculators and will eventually burst due to its decentralization and lack of a governing body (Cheah & Fry, 2015).

1.2 Methodology and Data Used

This thesis will be divided into two parts the first being theoretical and will include the history and evolution of currency, it will also illustrate the time-line of Cryptocurrency "Bitcoin" how it was founded and the philosophy behind it. It will also provide a comprehensive break down of all the elements used in the production of the cryptocurrency from its algorithm SHA256 (Secure Hash Algorithm 256-bit), Block-Chain-Technology, its origins and how it's the corner stone for the survival of any Cryptocurrency, it will also describe the process of pooling when mining for Bitcoin and the fees associated with it, the hardware used to collect the Bitcoins (Processors, Cables, Cooling Systems and Internet speed) and finally how it is virtually stored.

The second part of this thesis will be divided into two empirical parts, the first part will determine the fixed and variable costs that are needed in order to implement a cost of production model for mining Bitcoins and show whether it is profitable to mine them.

The second empirical part of this thesis will be an analysis of the costs in comparison to the market price of Bitcoin using ARDL, DOLS and finally FMOLS. The data set that will be used will start from the actual mining date of the first Bitcoin Jan 2009 and will end on the 28^{th} Feb 2018.

1.3 Aim of The Study

This thesis aims to give a comprehensive dissection of cryptocurrency and how it is created and mined and more essentially by the end of the empirical side we will be able to answer four key hypothesis's which are as follows:

Hypothesis 1: is gaining Bitcoin through mining a profitable venture?

Hypothesis 2: what empirical variables affect the market price of Bitcoin if any?

Hypothesis 3: who are the winners in the Bitcoin system, the Miners or the people exchanging it?

Hypothesis 4: after the last Bitcoin is mined will the market price for the cryptocurrency rise or drop?

1.4 Structure of the Study

This thesis will be made up of six chapters not including the introduction and will have the following flow: Chapter two, the literature review will set out to give a brief view of currency and the reasons behind its evolution towards virtual and cryptocurrencies. Chapter three will go into extensive information about money as a medium of exchange its history and how it changed to adapt or merge with the time it was in. chapter four will introduce cryptocurrency and its creation, as mentioned previously it will take its history and all the elements involved in creating and distributing the currency. It will discuss the two major bubble bursts in Bitcoin and the reasons behind it. The chapter will also highlight the main reason behind the cryptocurrencies existence by explaining the history behind Block-Chain-Technology. Chapter five will introduce the first stage of the empirical aspect of this thesis, it will illustrate the data needed to formulate a fixed and variable cost, how to calculate the quantity of Bitcoins produced per working day and produce a cost of production model that will be compared to the market price and finally conclude by identifying if the process of mining for bitcoin is profitable or not. Chapter six will introduce the second empirical stage where the data formulated in the first empirical part is used to identify whether the variables formulated have any direct impact on the market price of Bitcoin. Finally, chapter 7 will conclude the findings and discusses the implications cryptocurrency has.

Chapter 2

LITERATURE REVIEW

2.1 Cryptocurrency Overview

Cryptocurrency simply defined is a virtual medium of exchange and store of value. It has no true intrinsic value for it is not tangible. Its protects itself from duplication and counterfeiting by using cryptography a system that takes plain text and converts it into mathematical code and vice-versa.

Satoshi Nakamoto an unknown person or group of people assembled bitcoin in late 2009 by authoring a paper "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto, 2008) which was spread to cryptography enthusiasts using a cryptography mailing list describing a new form a virtual currency. The main element behind its establishment was that it was anonymous and outside the banking system (Brito & Castillo, BITCOIN A Primer for Policymakers, 2013)

The idea of a cryptocurrency is not at all new it was introduced in the mid 80's by David Chaum he proposed introducing a virtual currency that used cryptographic protocols which would secure and ensure personal privacy via online transactions (Chaum, 1983). That's why an emphasis on the word assembled was used for he/they did not create nor did he/they invent something new but rather took two existing theories and combined them to establish Bitcoin, a virtual currency that cannot be corrupted by using cryptography and decentralized it by using block chain technology (explained in chapter 4).

The emergence of the cryptocurrency BITCOIN in the year 2009 had literally no impact on the way trade or finance was conducted. It had no interest in all sectors may they be Financial, Government or Academic. It wasn't till the end of 2013 when its price started to increase at a very significant pace from a mere 13.46 U. S dollars to 753.62 U. S Dollars did people start to notice it (bitcoin.com, 2018).

As of August 2018 there are over 1754 different types of cryptocurrencies (coinmarketcap.com, 2018) with a market capitalization of $251,495,322,354 (coinmarketcap.com, 2018) but emphasis is mainly focused on BITCOIN for it holds over 47.6% of the market with a market capitalization of $119,604,510,166 (bitcoin.com, 2018)

Before the year 2014 not allot of studies were published on BITCOIN, it was not till its price sky rocketed in 2013 that people started taking interest in this form of cryptocurrency (Barlin, 2017) and even then due to its abnormal price fluctuations the financial, governmental and academic worlds were divided into categories. Some were all for the cryptocurrency stating that it followed the pattern of supply and demand and an efficient market structure (Bartos, 2015) others also were with the cryptocurrency and started researching how to introduce their own cryptocurrency for they realized that for the past decade cash has been rarely used and has been substituted with a various forms of electronic currencies (Skingsley, 2016).

On the other side of the spectrum there were the people against the cryptocurrency stating that it was a speculative bubble with no true value and at one point or the other would collapse (Cheah & Fry, 2015) while others believed that it was not in great favour for policy makers and banks due to its anonymity (Barrdear & Kumhof, 2017)

2.2 Reasons Behind Introduction of Cryptocurrency "BITCOIN"

There are two main circulating theories on the reason behind introducing this cryptocurrency BITCOIN to the market. The first being that Over the past century due to the expansion of commerce and the market and the ever increasing hunger to penetrate new markets and to increase productivity and profits the world has literally become a global village (Goyal, van der Leij, & Moraga-González, 2006). The need to decrease the time and increase the effeciancy of all transactions in this buisness world cannot be ignored or neglected. Taking these points into consideration the availabity of an easy flowing currency that is applicable and accepted by all parties and most importantly can be moved from sender to recipets as fast as possible resulted in the need to create a new form of payment method "BITCOIN"

The 2^{nd} thoery being In the year 2008 the mortgage criss that hit the United States had a negative domino effect on the rest of the world which led to a recession that devestated the lives of millions across the globe. This crisis led to a significant decrease in the trust in the way governments operated and allocated there resources (money) (Sapienza & Zingales, 2012). This way very noticable when the governments bailed out the large corporations and did nothing legally when these resources were disbursed as bonuses for individuals that were actually reposible for the crisis to begin with. Due to these incidents BITCOIN was introduced as an alternative to the current financial system Nakamoto believed that by introducing it into the market he/they would create a platform that would eventually replace fiat currency which would make it literally impossible for government , financial regulators and institutions to have any control of the production and the market price of the cryptocurrency. Nakamoto also believed that it would end financial crisis by the introduction of a currency that cannot be duplicated and manipulated would eventually eliminate the third parties that were the actual cause of the 2008 financial crisis (Nakamoto, 2008)

2.3 How is Cryptocurrency “BITCOIN” Valued?

One of the main reasons behind the value of any known commodity or currency is how people perceive it, meaning that if people believe it has value or trust in its vendor then value does exist, on the other hand if people’s perception in the commodity or currency is shaken then it would literally be worthless.

There are several factors that should be taken into consideration when valuing a currency, its intrinsic value meaning how tangible it is and how much did it cost to create or manufacture, its rarity which follows the supply and demand function meaning that as long as supply of a given currency is less or equal to it demand then its value will never decrease “inflation” and finally it acceptance in the general public as a medium of exchange.

now since BITCOIN is considered as virtual fiat money it should literally have no intrinsic value in exception to the value that people place in it. Taking all these factors into consideration how is BITCOIN valued?

It is estimated that around the year 2140 the last of the bitcoins will be mined which means that there will be 21 million bitcoins in circulation (Bitcoin Block Reward Halving Countdown, 2018) from this aspect it would be safe to assume that in theory as long as the demand for BITCOINS increases and due to its limited supply the price of BITCOIN will always rise.

The main reason behind the establishment of BITCOIN was to act as an alternative to fiat money but since it started its circulation in late 2009 till this present day it has not fulfilled its function as a currency. This is mainly due to the fact that not allot of vendors or banks have approved it as a legal tender. The price of BITCOIN has mainly been due to speculators and allot of people are basically using it as an asset instead of its original purpose a currency (Glaser et al., 2014).

Chapter 3

CRYPTOCURRENCY "BITCOIN"

3.1 What Is Cryptocurrency "BITCOIN"

Cryptocurrency Is basically a virtual currency which was established to act as a medium of exchange and in some cases a store of value, it uses cryptography which is a system in which plain text is transformed into code and when needed that code is reversed into plain text again. The reason behind using cryptography is to ensure privacy and security for all users and at the same time as a verification platform.

Over all it has allot of common features with e-money "electronic money". It's not tangible, again it is used as a medium of exchange which is used as an equivalent to cash and is mainly used through the internet (Zähres, 2012).

This thesis will mainly be focusing on BITCOIN as a cryptocurrency, even though there are thousands of different types of cryptocurrencies the concentration will be on BITCOIN for it holds the largest market share (coinmarketcap.com, 2018) and has been the most controversial and publicized cryptocurrency due to the philosophy behind its establishment.

As mentioned previously the concept of a virtual currency is not new (Chaum, 1983) see also (Kauffman & Walden, 2001) researched the possibility of establishing a digital currency that was decentralized and did not need a third party to verify any of its transactions. It should be mentioned that unlike earlier virtual currencies or e-money BITCOIN does not represent nor is it backed up by any legal tender such as the Dollar or Euro.

There are a few elements that make cryptocurrency BITCOIN unlike its predecessors. The creation and disbursement of the BITCOIN currency is controlled by an algorithm which is monitored by the public and has no dependence on any central bank or monetary policy, the process of verifying any given transaction does not have any involvement from a third governing body meaning it is fully decentralized and finally the medium in which the currency is stored does not carry any personal information of the owner which allows the holders of the BITCOINS to remain completely anonymous. (Karlstrøm, 2014)

With all that said the key element that gave BITCOIN its initial competitive advantage was how Satoshi Nakamoto solved the double-spending, fraud and hacking problems. In all transactions performed in the past and till this present day there is always a third monitoring and verifying body such as banks or financial institution that confirm the transaction is correct or void, but due to their centralization these bodies were prone to delays, hacks, double-spending and fraud (Everaere, Simplot-Ryl, & Traoré, 2010). Satoshi Nakamoto tackled this issue by making all transactions appear on a public ledger that was visible to anyone, this ledger would be later verified by more than one party by using peer-to-peer (P2P) technology meaning that in order for any fraudulent activity or double spending to take place a person or entity would have to hack everyone that had a copy of that ledger which is literally impossible due to the amount of people verifying these ledgers today (Evans, 2014). By using the P2P platform and making the ledgers visible to the public Satoshi Nakamoto finally managed to decentralize BITCOIN.

3.2 Mechanisms for Obtaining BITCOIN

Now since we have managed to define what a cryptocurrency is and the reason behind the growing interest in it, the next step in this process would be how does a person obtain this currency there are numerous ways for any given individuals to get their hands on BITCOIN but the three mostly used methods to date are as follows:

1. Obtaining BITCOINS as a method of payment.
2. Obtaining BITCOINS through the process of mining and verification.
3. Obtaining BITCOINS through trading.

3.2.1 Obtaining BITCOIN as a Payment Method.

The main reason behind the creation of BITCOIN was for it to be used as a medium of exchange, meaning an individual would pay for an item or services that he or she required by using BITCOIN. In order to do that the sender and the receiver of BITCOIN would need to open a software that acts as a wallet for the sending and receiving of cryptocurrency. These wallets can be downloaded on your laptop, pc, or your mobile phone and with it you will get a special QR-code Figure 3 at appendix section.

After the process of obtaining the wallet and QR-code you can send a receive BITCOINS instantly. It should be noted that because BITCOIN is not pegged to any currency, the receiver in this case would have to convert the desired currency (Dollar, Sterling, Euro) into the amount of BITCOINS. This could be risky because BITCOIN has proved to be a very volatile currency.

An example of this volatility can clearly be seen by the first ever purchase done by BITCOIN. a programmer Laszlo Hanyecz that started mining BITCOINS since it started made an agreement with a pizza vendor on the 22nd of May 2010 to pay for two pizzas for the lump sum of 10,000 BITCOINS (The market price of BITCOIN on the specific date was zero) (Yermack, 2013) the price of these two pizzas on the 26th of February 2018 would be 95,897,200 U.S. Dollars making these two pizzas the most expensive pizzas ever to be purchased.

3.2.2 Obtaining BITCOIN Through Trading.

Another way of obtaining BITCOIN is by simply buying BITCOINS from the market and wait for the price to rise in which you would make a profit, but if the price falls you would lose money making it a very speculative market and that has been proven time and time again by the sudden rise and fall of BITCOIN prices sometimes for no apparent reason.

3.2.3 Obtaining BITCOIN Through the Process of Mining and Verification.

The most common way of obtaining BITCOIN is through the process of mining. It's an online process in which all transactions are verified and added to the ledger that is public to everyone. BITCOINS are generated in two ways when mining is implemented, its either a percentage fee given upon the verification of certain block, or through the generation of new BITCOINS by successfully solving a computational puzzle (Block Reward). It should be noted that mining is the corner stone for the existence of BITCOIN for if the process of mining stops all transactions that occurred online would not and could not be verified plus no new BITCOINS would be produced to go into circulation.

When BITCOIN started its circulation in the year 2009 Satoshi Nakamoto capped the number of BITCOINS that will ever be produced at 21 million. The reason behind fixing the amount of BITCOINS in circulation was to maintain its value, meaning that after the 21 million BITCOINS are in circulation no new BITCOINS will ever be produced so unlike normal fiat money inflation in theory should not occur for the supply of the BITCOINS will never surpass its demand. (Nakamoto, 2008).

When BITCOIN started to be produced in the 2009 there were no real transactions for it was a new currency, in the beginning Satoshi Nakamoto incentivized the solving of blocks by rewarding the people that solved the blocks with BITCOINS. In the year 2009 the number of BITCOINS rewarded for successfully solving a block was 50 BITCOINS. As the number of miners increased the reward for solving the blocks decreased by half and this occurred every 210,000 blocks (one block is successfully mined every 10 minutes) which is approximately every 4 years. When this thesis was being done the block reward was 12.5 BITCOINS and by 2020 it should be halved again to be 6.25 BITCOINS per successful block. The diminishing of the reward will ultimately lead to a total circulation of 21 million BITCOINS by the year 2140.

After the incentive was created to mine BITCOINS and transactions started to take place, all the pending transactions started to get placed into the block for them to be verified in the public ledger, this was essential to implement to maintain the decentralisation of BITCOIN. A fee was associated with the verification of every transaction this way the ledger will always be updated and no fraud will take place but more importantly that process of mining which as mentioned earlier is the corner stone for BITCOINS survival will not stop.

3.3 Advantages and Disadvantages of Cryptocurrency BITCOIN

In this section the thesis will be discussing what makes cryptocurrency BITCOIN so alluring in today's market we will try to establish what are the main advantages and disadvantages of using this virtual currency may it be as a medium of exchange or a store of value.

One of the most essential factors that contributed in BITCOIN being studied and initially accepted by the world was its decentralization, the fact that there is a new form of currency that does not go by the norms of being regulated by a government or any governing body was very enticing to allot of people (Blundell-Wignall, 2014). The trust in BITCOIN was held by a mathematical computation which could not be corrupted and was very transparent. The transparency made people want it for they believed that through that they would be showing their dissatisfaction with the ways their governments and financial institution were handling things especially after the financial crisis of 2008 (Bradbury, 2013).

Another advantage that occurred from decentralization was the elimination of the third party, meaning that any person can transfer or receive BITCOINS with minimal or no extra charges unlike other transfer platforms such as Money Gram and Western Union. The fact that you do not have to rely on a third party for your transactions gave way to being able to send and receive BITCOINS at any time and to any location worldwide (Rogojanu & Badea, 2014)

Another aspect that has contradicting views is the anonymity associated with BITCOIN. it is argued that the private information of any given individual is not needed hence protecting his identity. On the other hand, the opposing side state that this is one of the most crucial elements behind the weakness of the virtual currency and the reason behind its none acceptance by governments. Their opinion was that the anonymity of the individual in any given transactions only proves that illegal activities were taking place and would give a great platform to shadow economies, money laundering and drug dealing. Due to anonymity it would decrease if not erase the chance of direct marketing opportunities for in these cases you would not know what is purchased and even if you did you would not know whom it was purchased by (Piotrowicz & Cuthbertson, 2014).

The capping of the cryptocurrency at 21 million BITCOINS to ever be in circulation would shield it against inflation because as mentioned before as long as the supply of BITCOINS is less than the demand for it the reason behind inflation would not occur, but that also causes a disadvantage for if the use of BITCOINS increases due to its increasing demand that would cause the currency to appreciate , this issue was tackled by introducing a lower denomination of the BITCOIN which is the SATOSHI (0.00000001 ฿) (www.btcsatoshi.com, 2018).

With all that mentioned one leading disadvantage for BITCOIN so far is its price volatility. The capped limit on the BITCOINS circulating in the market tries to follow the strategy of gold as an asset “ Figure 8 Appendix section” but when compared to gold in its price fluctuations it can easily be determined that at the moment BITCOIN has noticeable problems in the volatility of its price. (Yermack, 2013)

Another key disadvantage for the cryptocurrency is that it could be hacked. The actual transactions and sending and receiving of BITCOINS cannot be hacked due to the technology behind it (Block-Chain-Technology) but after the transaction has taken place and the currency is being stored in an individual’s virtual wallet only then can hacking can take place (Brito, Shadab, & Castillo, Bitcoin Financial Regulation: Securities,Derivatives, Prediction Markets, and Gambling, 2014)

Furthermore, the storing of BITCOIN unlike other currencies does not generate any cash flows, meaning that if people used the American Dollar as a store of value and kept it in the bank that individual would generate extra cash through the interest rate, while in BITCOIN the only money that can be generated is through its price fluctuations and in some cases that could lead to a loss in money rather than a gain (Blundell-Wignall, 2014).

Chapter 4

THEORETICAL SETTING PART ONE

4.1 Theoretical Settings Part One

Since the sudden price spike in BITCOIN several studies have been implemented on the reason behind the increase in price and how its price has been formulated to begin with. Some studies have focused on the supply and demand function and believed that the price of BITCOIN rises due to it limited supply (Buchholz, Delaney, & Warren, 2012). Other studies stated that the rise in BITCOIN was due to its attractiveness to investors as a speculative asset (Kristoufek, 2013) (Yermack, 2013).Others have tried to figure out the reason behind the volatility in the prices associated with BITCOIN rather than the actual determinants for its price to begin with (Katsiampa, 2017)

Very few studies have been implemented on the cost determinants of producing BITCONS and then comparing it to its market price to see if there is any logical explanation behind its pricing (Hayes, 2015)

In his paper Hayes calculates the cost of actually producing BITCOIN for he believes that since a cost is incurred while producing the BITCOIN then it would logically have intrinsic value unlike (Yermack, 2013) who states in his papers that BITCOIN and basically all cryptocurrencies have no true intrinsic value.

In this thesis will be producing a cost of production model but unlike Hayes this thesis will have a broader data set and will include several additional variables that Hayes considered negligible.

4.2 Data

In this thesis we will be using a data set that starts from the first day BITCOIN was actually mined which starts on the 10th January 2009 and ends on 26th of February 2018. The variable that will be used to calculate the production model will be divided into two parts, the first part will be composed of the algorithms and computational elements needed to mine a BITCOIN there are several ways to calculate it but for the sake of comparison this thesis will implement the same equation as (Hayes, 2015) the second part will consist of all fixed and variable costs associated with producing a BITCOIN.

1. Algorithms and computational elements:
    - Hashing Rate: This is the numerical value of the power associated with the BITCOIN network. This is used for the network must have complex cryptography for security reasons. For example, if the hash rate was 5 Th0/s it means that it could make up to 5 trillion calculations a second. (www.blockchain.com/charts/hash-rate, 2017)
    - Difficulty: this also is a mathematical value that shows the level of difficulty it is to find a hash that will enable you to solve a block. (www.blockchain.com/charts/difficulty, 2017)
    - Secure Hash Algorithm 256-bit: this is the algorithm that BITCOIN uses for its encryption and protocol functions in it network.
    - Gigahertz: a measure of the speed or frequency used to solve a block, the greater the GH/s the better chance for solving a block.

2. Fixed and variable costs:
    - Hardware: all the components such as the wiring and processors (LLC H. S., 2011-2018)
    - Electricity: the cost of electricity per kilo watt. (Electric Power Monthly, 2018)
    - Internet connectivity: the cost incurred for ensuring an internet connection is running at all time. (LLC O. D., 2018)
    - Pooling fee (1%): the price needed to be paid for the ability to join a group of people to combine your computational power to have a greater chance at solving a block.

4.3 Methodology

As mentioned in the previous section this thesis will implement that same formulas used by Hayes (Hayes, 2015). Firstly, we will calculate the number of BITCOINS that can be mined with the given computational power and speed that we have. In the second stage we will calculate the cost of producing these BITCOINS. Finally, we will divide the cost of producing the BITCOINS with the amount of BITCOINS produced to give us the marginal cost for the given time period. The only exception between the way this thesis calculates the overall value of BITCOIN is unlike Hayes we incorporated the cost of hardware, internet connectivity and pooling fee (when applicable) and finally we calculated the profit/loss by the end of each Gregorian year.

Equation 1 illustrated below is used to calculate the amount of BITCOINS mined each day by calculating the Hash Rate, Difficulty and block reward for that given time is as follows:

$$BTC/day^{*} = \left[(\beta * \rho)/(\delta * 2^{32})/\sec_{hr}\right] * hr_{day} \tag{1}$$

After we have determined the amount of BITCOINS produced we will calculate the cost of producing that BITCOIN by taking the cost of electricity, hardware, internet and again pooling when applicable, equation 2 and 3

$$E_{day} = (P.per.kW * 24hr_{day} * W.per.GH / s) * (GH / 1000) \quad (2)$$

$$TC_{day} = EC_{day} + HC_{day} + IC_{day} + PC_{day} \quad (3)$$

After calculating the two formulas we will take the amount of BITCOINS produced per day and divide it by the cost of producing that BITCOIN, by doing so it will give us the marginal cost of producing that coin in order for us to compare it to the market price of that BITCOIN on that given day. (equation 4 and 5)

$$p^* = E_{day} / (BTC / day^*) \quad (4)$$

$$p^* = TC_{day} / (BTC / day^*) \quad (5)$$

4.4 Empirical Analysis

In this part this thesis will be calculating two different parts for the production model , in the first part we will be using the same date used by (Hayes, 2015) and compare his findings to see if the added variable in this thesis have any impact on the cost of production. We will then take the marginal price that was calculated and compare it to the market price of bitcoin on that given date.

The second part is this thesis will calculate the actual cost of production of BITCOIN per year and that also will have two parts one of which the BITCOINS mined are sold immediately and the other with the BITCOINS mined are sold at the end of that specific year. the results will show us whether it's more profitable to buy BITCOIN or mine BITCOIN.

4.4.1 Cost of production model

As mentioned above this thesis will be using the same formula as (Hayes, 2015). We will first calculate it in his way but will use exact information rather than hypotheticals, we will then do the same calculation with the newly added variables (cost of hardware, internet and pooling fee when applicable.) and finally we will compare our findings to see if the newly added variables had any effect on the overall cost of production and the marginal cost.

Using his equation with no newly added variables we first calculate the amount of electricity needed to operate an average ASIC mining rig (all hardware). (equation 01)

$$E_{day} = \left(P.per.kW * 24hr_{day} * W.per.GH / s\right) * \left(GH / 1000\right)$$

The price of electricity on March 19th 2015 was (0.1265 cents per kilowatt hour) and the ASIC consumed 1.05 J/GH therefor the average cost per day for 3270.378692 GH/s of hashing power would be as follows:

Eday= (0.1265·24 ·1.05) (3270/ 1,000) = **10.42531**

After we have established that operating that specific ASIC mining rig will cost (10.42411 dollars a day) we start using the second equation to calculate how many BITCOINS that rig can produce per day which would be as follows:

$$BTC/day^{*} = \left[(\beta * \rho)/(\delta * 2^{32})/\sec_{hr}\right] * hr_{day}$$

Again going back to the data from March 19th 2015 we would get a hash rate of 3270.378692 Giga-Hashes (GH/s), a difficulty of 47427554951**,** a block reward of 25, 3600 seconds per hour, 24 hours per day and finally the SHA-256D algorithm which is 4294967296 (2^32)

$$BTC/day^{*} = \left[(25 * 3270.378692)/(47427554951 * 2^{32})/3600\right] * 24 = \underline{\mathbf{0.034679}}$$

now that we have established that in order to produce 0.034679 BITCOINS it would cost 10.42531 Dollars we finally calculate the marginal cost of this production and compare it to the market price of BITCOIN on the 19th of March 2015 and this is done as follows:

$$p^{*} = E_{day}/(BTC/day^{*})$$

$$10.42531/(0.034679) = 300.627$$

Looking at the market price for BITCOIN on the 19th of March 2015 which was 265.06 dollars, even though the price is close to the marginal cost we realize that on that specific day mining for BITCOINS would in the long run incur a loss (taking into consideration that the price and all other variables remain constant.)

Now that we have established that by just using the cost of electricity, it can greatly affect the profitability in mining BITCOIN, we will implement the same formula again but with the newly added variables being the cost of hardware, internet and pooling fees. Through logic we know that it will increase the marginal cost but want to confirm if the new variables have a noticeable impact or not.

we will follow the same steps in equation 1 and 2 and will get the same results, after that we will calculate the total cost of production by adding the new variables using equation

$$TC_{day} = EC_{day} + HC_{day} + IC_{day} + PC_{day}$$

Since we already have the cost of electricity EC_{day} we know add the cost of hardware , which would be the overall cost of setting up the ASIC rig with all its components and dividing that cost by 365 to get your incurred cost per day HC_{day} , we do the same for the cost of your yearly internet IC_{day} and finally the pooling fee which is always capped at 1 % of the amount of bitcoins produced PC_{day} .after all the information has been gathered we calculate the total cost as follows:

$$36.524716691 = 10.42531 + 23.12328767 + 2.8842 + 0.091919021$$

After calculating the total cost, we perform the calculation for the marginal cost and again compare it to the market price of BITCOIN on the 19th of March 2015 which is as follows

$$p^* = TC_{day} / \left(BTC / day^* \right)$$

$$1053.2228925574\$ = 36.524716691 / .034679$$

as you can see from the results the difference in marginal cost is very noticeable which in any ordinary circumstances would give a very hard signal to stop mining yet again this is taking into consideration that the price and all other variable remain constant.(please note that if we use the exact hypothetical calculation as in (Hayes, 2015) and just added the new variables the marginal cost would spike to 3444.48 dollars)

In this part we will use our cost of production model with all the new variables and calculate the cost of producing BITCOINS since its beginning on the 10th of January 2009 till the 26th of February 2018. This is done due to the great volatility in BITCOINS market price because as seen from the equations used previously we can get marginal costs that are way above the market price. Since we only used one day it does not give us an accurate reading of the complete data set.

After the completion of the calculations of all 2970 data sets two tables will conclude the profit incurred by mining BITCOIN. The first table will show the profit made if the amount of BITCOINS produced were sold on the same day they were produced. The second tale will again show the profit made if BITCOIN was gathered and only sold at the end of that specific year. The results will give us an idea about the profitability of mining and at the same time will show if BITCOIN is better off being exchanged daily or used as a medium of storage.

4.4.2 Profitability Through Daily Sales

Since the market price is available (coinmarketcap.com, 2018) and now we have an accurate picture on the cost of mining per day we will take it a step further and see if the cost of mining is worth the effort taking into consideration that the amount of BITCOINS mined a day will immediately be sold (table 01 appendix section) prices were not entered in the table because we have over 2970 costs for the time period for a detailed price and cost view see (appendix). As seen from the table using the assumption that every BITCOIN mined and is sold on the same day it was mined is a venture that ends up with incurring a loss except for the years 2017 and 2018 till the 26th February. The spike in BITCOINS price in 2014 made no difference to the amount of profit gained from mining and this is due to the costs that are incurred due to the investment in hardware, extra charges in electricity and internet and that does not include pooling because till 2014 the BITCOIN network did not have allot of miner competing to solve blocks and receive the block rewards.

4.4.3 Profitability Through End of Year Sales

Taking BITCOINS price volatility in the market we went a step further and produced a table in which the BITCOINS produced are to be sold at the market price for the last day of the year (December 31st). by doing so we could see if holding on to the BITCOINS mined is a better alternative to selling it immediately. "Table 2 appendix section"

As seen from the table the amount of years making profit from mining BITCOINS doubles and is most profitable in the year 2017 with a total profit of 77,100 U.S Dollars. From the results in this table it implies that holding on to the BITCOINS mined is more profitable than selling it on a daily basis.

Chapter 5

THEORETICAL SETTING PART TWO

5.1 Theoretical Settings Part Two

In the year 2009 a new form of currency emerged in the financial markets, it did not gain much attention from both the financial and academic institutions for they believed that it would not survive. The reason behind the assumption that this new virtual currency "Cryptocurrency" will not survive was derived because of two reasons the first being that they believed the virtual currency did not have any true intrinsic value and the second reason being that it was a decentralised currency with no proper regulatory body.

By the year 2014 an explosive interest in the cryptocurrency started to take form especially in "Bitcoin" due to its unprecedented rise in price from a mere 0.05 cents in 2010 to a market price of 957.35 dollars in 2014. The aim of this thesis is to place empirical evidence on how cryptocurrencies are valued. The thesis will also provide evidence that cryptocurrency has some intrinsic value because of the investments made in mining it. The variables that make the cryptocurrency have any value. Change according to the cryptocurrencies relation to hashing power (hardware), energy consumption to produce one crypto coin, the pooling fee, internet connectivity and its cost and finally the algorithmic difficulty in mining it. In this thesis, the functional relationship will be used to investigate the effects of fixed cost, variable cost and pooling fee on the market price of bitcoin currency. So, the following functions will be used to observe functional relationships of this study

$$MP_t = f\left(FC_t^{\beta_1}, VC_t^{\beta_2}, PF_t^{\beta_3}\right) \tag{6}$$

where t is time periods of proxy measures from 2009 to 2018, MP is the market price of the bitcoin crypto currency; FC is the fixed cost that includes hashing power (hardware) and internet connectivity; VC is the variable cost that is energy consumption i.e. electricity cost where it is generated by the multiplication of power consumption with the cost per kilowatt; and finally PF is the pooling fee. β_1, β_2, and β_3 are the coefficients of regressors. As it mentioned previously, it is expected that some of the valuing variables will have a positive effect on the actual price while other may have a negative effect on the value of the cryptocurrency.

To characterize the growth effects in the value of crypto currency in the long run, in the first equation all of the variables will be expressed through a logarithmic form, by doing so the equation (6) becomes;

$$\ln MP_t = \beta_0 + \beta_1 \ln FC_t + \beta_2 \ln VC_t + \beta_3 \ln PF_t + \varepsilon_t \tag{7}$$

where t denotes time period, lnMP is the natural logarithm of market price of bitcoin, lnFC is the natural logarithm of the fixed cost, lnVC is the natural logarithm of variable cost, lnPF is the natural logarithm of the pooling fee, and ε is the error disturbance.

The dependent variables in equation (7) may not quickly conform to long-term equilibrium levels following a change in their determinants. Therefore, the speed of adjustment between the short-term and long-term levels of the dependent variables can be captured by estimating the following error correction models:

$$\Delta \ln MP_t = \beta_0 + \sum_{j=1}^{n} \beta_1 \Delta \ln MP_{t-j} + \sum_{j=0}^{n} \beta_2 \Delta \ln FC_{t-j} + \sum_{j=0}^{n} \beta_3 \Delta \ln VC_{t-j} + \sum_{j=0}^{n} \beta_4 \Delta \ln PF_{t-j}$$

$$+ \beta_5 \varepsilon_{t-1} + u_t \qquad (8)$$

where Δ represents a change in the MP, FC, VC and PF variables, and ε_{t-1} is the one period lagged error correction term (ECT), estimated from equation (7). The ECT in equation (8) demonstrates how rapidly the disequilibrium between the short-run and long-run values of the dependent variables is abolished in each period. The expected indication of the error correction term is theoretically negative (Gujarati, 2013)

5.2 Data

Daily data covering the period from 10 January 2009 to 26 February 2018 will be utilized in this thesis. The variables of the study are the market price of bitcoin (MP), FC as fixed cost, VC as variable cost, and the pooling fee (PF).

5.3 Methodology

As it mentioned previously, daily data will be use to employed several analyses. First, variables will be checked whether they are stationary or not. Then co-integration tests will be employed to investigate the existence of a co-integration vector. Third, auto regressive distributed lag (ARDL) methods have been employed to estimate long-run and short-run models, in addition to the error correction term. Finally, to support the earlier findings, Granger causality tests through the block exogeneity approach has been carried out.

5.3.1 Unit Root Tests

Several unit root tests will be carried out to detect stationary nature of variables. IN this thesis, Augmented Dickey-Fuller (ADF), Phillips and Perron (PP), and Dickey-Fuller GLS (DF-GLS) will be carried out. All three-unit root tests use the null hypothesis of the existence of unit root versus the alternative of stationary. The unit root tests will be carried out for both level and first differences of MP, FC, VC, and PF.

5.3.2 Bound Test of Co-integration

In the following step, long run relationship will be examined to investigate whether variables interact each other in the long run or not. Although (Johansen & Juselius, 1990) (Granger, 1969)and (Johansen, 1988)are some of important co-integration tests, in this thesis the bounds test for co-integration within the ARDL (the autoregressive distributed lag) modelling approach will be adopted in to investigate a long-term relationship between the variables under consideration. The bounds test for co-integration, that has using the null hypothesis of no co-integration, within the ARDL (the autoregressive distributed lag) modelling has been developed by (Pesaran, Shin, & Smith, 2001)This model can be applied irrespective of the order of integration of variables, where whether regressors are purely I (0), purely I (1), or mixed order of co-integration.

5.3.3 Level Estimations and Error Correction Model

In the case of existence of co-integration vector, level estimation will be carried out in order to examine long-run relationship between the variables of interest. Moreover, the conditional error correction model (ECM) using the ARDL approach will be employed to determine short-run coefficients of the variables of interest and error correction term. Error correction model will be determined by using equation (8), which is emphasized in the previous chapter, to investigate speed of adjustment between short-run and long-run levels of market price of bitcoin (MP).

5.3.4 Granger Causality Tests

In light of the long-run relationship proposed in equation (7) of this study, Granger causality tests are performed under the block exogeneity Wald tests through the ECM mechanism. (Granger, 1969) proposed causality test in order to determine whether one-time series is utile to predict another time series or not. The aim of utilizing Granger causality under block exogenity Wald test is to detect whether the lag of one variable can cause any other variables in vector autoregressive system. The Granger causality tests in the present study can be indicated as follows:

$$\begin{bmatrix} \Delta \ln MP_t \\ \Delta \ln FC_t \\ \Delta \ln VC_t \\ \Delta \ln PF_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \end{bmatrix} + \begin{bmatrix} \partial_{11.1} & \partial_{12.1} & \partial_{13.1} & \partial_{14.1} & \partial_{15.1} \\ \partial_{21.1} & \partial_{22.1} & \partial_{23.1} & \partial_{24.1} & \partial_{25.1} \\ \partial_{31.1} & \partial_{32.1} & \partial_{33.1} & \partial_{34.1} & \partial_{35.1} \\ \partial_{41.1} & \partial_{42.1} & \partial_{43.1} & \partial_{44.1} & \partial_{45.1} \end{bmatrix} \begin{bmatrix} \Delta \ln MP_{2t-i} \\ \Delta \ln FC_{t-1} \\ \Delta \ln VC_{t-1} \\ \Delta \ln PF_{t-1} \end{bmatrix} + \ldots\ldots +$$

$$+ \begin{bmatrix} \partial_{11.i} & \partial_{12.i} & \partial_{13.i} & \partial_{14.i} & \partial_{15.i} \\ \partial_{21.i} & \partial_{22.i} & \partial_{23.i} & \partial_{24.i} & \partial_{25.i} \\ \partial_{31.i} & \partial_{32.i} & \partial_{33.i} & \partial_{34.i} & \partial_{35.i} \\ \partial_{41.i} & \partial_{42.i} & \partial_{43.i} & \partial_{44.i} & \partial_{45.i} \end{bmatrix} \begin{bmatrix} \Delta \ln MP_{2t-i} \\ \Delta \ln FC_{t-i} \\ \Delta \ln VC_{t-i} \\ \Delta \ln PF_{t-i} \end{bmatrix} + \begin{bmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \\ \phi_4 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \\ e_{4,t} \end{bmatrix} \quad (9)$$

where Δ stands for the difference operator. ECT_{t-1} is the lagged error correction term derived from the long-run equilibrium model. Finally, $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$, and $\varepsilon_{4,t}$ are mean zero, identically independent errors and a finite covariance matrix. The ECMs for the causality test must to meet the condition of a statistically significant chi-square (χ^2) statistic(s) to show that long-run and short-run causations are present.

5.4 Empirical Analysis

In this chapter, empirical analysis includes unit root tests, bound tests and error correction models that will be carried out using the ARDL methodology. In the initial step, unit root tests will be carried out in order to investigate the stationary nature of the variables taken into consideration. Then the bound test for co-integration will be carried out to detect the long-term relationship between the variables under consideration. In addition, error correction models will be examined to determine error correction term, short-term coefficients and long-term coefficients. In all the estimation E-views 8 will be used to carried out tests. Prior to the estimations, the descriptive statistics of all series under consideration has been illustrated in “Table 3 appendix section”.

5.4.1 Unit Root Test

In this thesis, Augmented Dickey-Fuller (ADF), Phillips and Perron (PP), and Dickey-Fuller GLS (DF-GLS) will be carried out to detect stationary nature of variables. “Table 4 appendix section” illustrates the unit root test results. The unit root tests for ln MP reveals that the series is non-stationary at level form, this is because all of the unit root tests failed to reject null hypothesis. However, Augemented Dickey-Fuller (ADF) and Phillips and Perron (PP) unit root tests reject the null hypothesis of unit root in first differences in all three models, that are the model with an intercept and trend; the model with an intercept and without trend; and finally the model without an intercept and trend. ADF and PP unit root tests suggest that lnMP is integrated of order one I (1).

The unit root test for the level forms of lnFC and lnVC reveals that the series are non-stationary at level form, this is because all of the unit root tests failed to reject null hypothesis. However, Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) unit root tests reject the null hypothesis of unit root in first differences in all three models, that are the model with an intercept and trend; the model with an intercept and without trend; and finally the model without an intercept and trend. Moreover, Dickey-Fuller GLS (DF-GLS) unit root test reject the null hypothesis of unit root in first differences in both models, that are the model with an intercept and trend; and the model with an intercept and without trend. ADF, PP, and DF-GLS unit root tests suggest that lnFC and lnVC are integrated of order one I (1).

On the other hand, Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) unit root tests reject the null hypothesis of unit root in level form of lnPF in the model without an intercept and trend. Additionally, Dickey-Fuller GLS (DF-GLS) unit root test reject the null hypothesis of unit root in level form of lnPF in the model with an intercept and trend. ADF, PP, and DF-GLS unit root tests suggest that lnPF is integrated of order one I (0). Therefore, lnPF is stationary in level form.

As a bottom line, lnPF is stationary at level, however lnMP, lnFC and lnVC becomes stationary at their first differences. Therefore, the series under consideration is integrated in mixed order.

5.4.2 Bound Tests for Co-integration

According to the result of unit root tests, it is obvious that the variables are not integrated in the same order. Therefore, ARDL modelling approach of bound test has to be employed instead of normal co-integration tests to investigate the long-run equilibrium relationship between market price of bitcoin with fixed cost, variable cost and pooling fee. Bound test results with and without deterministic trend has been illustrated in "Table 5 appendix section". Critical values for ARDL testing approach has been provided in "Table 6 in appendix section". The critical values of F ratios of the for the model with restricted deterministic trend (F_{IV}); the model with unrestricted deterministic trend (F_{V}); the model without deterministic trend (F_{III}) are taken from (Narayan, 1979–1990).

The critical values for t-statistics, T_V and T_{III} are the t-ratios for testing the null of no co-integration respectively with and without deterministic linear trend, are taken from (Pesaran, Shin, & Smith, 2001).F_{III}, F_{IV}, and F_V results will be used to determine whether co-integration vector exists or not, as a proof of long-run relationship between the variables. The results of bound tests, according to the F_{MP} (lnMP/ lnFC, lnVC, lnPF) model are illustrated in "Table 7 appendix section". In this thesis bound test results reveals the existence of long-run relationship between the variables, since it rejects the null hypothesis of no co-integration.

5.4.3 Level Estimations

Since the existence of co-integration between the variables of interest has been obtained, level estimation has been carried out to examine the interaction between the market price and regressors in long-run. All the regressors have demonstrated statistically significant relationship with market price in long-run. The coefficients of lnVC and lnPF are positive and highly significant, ($\beta = 13.040$, $p < .01$) and ($\beta = 0.969$, $p < .05$), respectively. On the other hand, lnFC is negative and statistically significant, ($\beta = -21.879$, $p < .10$).

Variable cost has positive effects on MP in the long-run. It shows that if variable cost rises by 1 %, MP will increase by 13.040 %. Pooling fee has positive effects on MP in the long-run. It shows that if pooling fee rises by 1 %, MP will increase by 0.969 %. Fixed cost has negative effects on MP in the long-run. It shows that if fixed cost rises by 1 %, MP will decrease by 21.879 %, as it is shown in "Table 8 appendix section".

5.4.4 Conditional Error Correction Model

The error correction term shows there is 1.08 % speed of adjustment, MP will converge its long-term equilibrium every year by FC, VC, and PF. While pooling fee is statistically significant at 1 % critical value, none of other regressors show statistically significant effect on MP. In short-run, pooling fee has positive effect on the market price of bitcoin. If pooling fee rises by 1 %, market price of bitcoin will increase by 0.447 %.

5.4.5 Granger Causality Test

Granger causality tests under the block exogeneity Wald tests through the error correction components for the short-run and long-run periods were investigated. The short- and long-run causations and χ^2 statistics of equation (4) are presented in "Table 9 appendix section".

There appears long-term causality that runs from fixed cost, variable cost, and pooling fee to market price since the overall $\chi 2$-statistic is not statistically significant ($\chi 2 = 16.209$, $p > .10$) when lnMP is dependent variable; the other overall $\chi 2$ statistics of the other models are not statistically significant except for the model when lnPF is dependent variable. It cannot be proven that the unidirectional long-run causality in equation (2) stems from fixed cost, variable cost, and pooling fee, resulting to market price, since the overall χ^2 statistics of the models are not statistically significant. There is only one short-run causality in this thesis. The unidirectional short-run causality runs from market price to pooling fee, since the related χ^2 statistic is statistically significant, ($\chi^2 = 106.204$, $p < 0.01$) and ($\chi^2 = 102.959$, $p < 0.01$), in without deterministic trend model and deterministic trend model, respectively.

Chapter 6

CONCLUSION

BITCOIN has travelled a long distance to get to where it is today, from its early beginning in 2009 as an ideology aimed at replacing real currency to fight corruption and government regulation and the ever persisting problem of inflation and deflation of currencies.

Even though it has been around for 9 years it is still to be used in mass as a medium of exchange for its full potential to be investigated. From the studies we have concluded that even though it was assembled to act as a medium of exchange it has not yet been fully adopted for that role.

When realized that it does not follow the supply demand function and has a very volatile market price. From the research implemented we can conclude that BITCOIN's price is mainly adopted through speculation and does not generate any cash flow as in normal currencies. Again from the research and the market price we can say that BITCOIN at the moment serves as a store of value rather than a medium of exchange.

The technology used in BITCOIN is unique and has created a platform for other currencies and even financial institutions and governments to implement it. The Block-Chain-Technology is what decentralizes BITCOIN but if this technology was to be used and regulated by governments and financial institutions then BITCOIN can actually be placed to the test.

From the cost of production side, it’s easy to see that BITCOIN does have intrinsic value which is calculated by the effort used to mine it. The process and costs of mining it are over simplified in all research aspects and proof for that is the ever increasing number of miner that want a piece of the pie.

This thesis has managed to illustrate the costs incurred in mining BITCOIN and that the variables that were introduced affect the cost of production substantially, but at the same time without the process of mining there would be no BITCOINS in circulation. The thesis also managed to show the opportunity cost of just buying BITCOINS from the market and making profit through speculation is far better than mining it.

Over all this thesis can conclude that BITCOIN with its present day adaptation is a speculative asset and can only be a speculative asset unless its function as a medium of exchange increases and that can only be done by increasing the amount of vendors willing to exchange their commodities with it.

That being said, after gathering all the variables and calculating the cost of production it raised new questions. With the amount of miner today and the amount of hardware and electricity consumed to mine for it what is the real cost that is incurred on a macro level? what will happen when the last BITCOIN is mined? meaning how will you keep the miner interested in mining when the pooling fees and the transaction fees would be considerably minimal to the amounts they are making today

REFERENCES

Kristoufek, L. (2013, December 4). BitCoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet era. *natureresearch*(3415).

Skingsley, C. (2016). Should the Riksbank issue e-krona? *FinTech Stockholm 2016, Berns.*

Barlin, R. (2017, June). Regulation on the Rise as Bitcoin Gains Popularity. *CPA Journal*.

Barrdear, J., & Kumhof, M. (2017). The Macroeconomics of Central-Bank-Issued Digital Currencies. *BNM monetary policy conference.* kuala lumpur.

Bartos, J. (2015, April 02). Does Bitcoin Follow the Hypothesis of efficient Market? *International Journal of Economic Sciences, IV(2),* 10-23.

Bitcoin Block Reward Halving Countdown. (2018, May 14, 9:58:37 AM). May Monday, 2018 tarihinde http://bitcoinblockhalf.com/. adresinden alındı

bitcoin.com. (2018, April 01). *https://charts.bitcoin.com/chart/price#0*. www.bitcoin.com. adresinden alındı

Blundell-Wignall, A. (2014). "The Bitcoin Question" Currency Versus Trust-Less Transfer. *OECD Working Papers on Finance, Insurance and Private Pensions.*

37. OECD Publishing. http://dx.doi.org/10.1787/5jz2pwjd9t20-en adresinden alındı

Bradbury, D. (2013, November). The problem with Bitcoin. *Computer Fraud & Security*, s. 5–8.

Brito, J., & Castillo, A. (2013). BITCOIN A Primer for Policymakers. *BITCOIN A Primer for Policymakers* (2 b.). içinde Mercatus Center George Mason University. mercatus.org adresinden alındı

Brito, J., Shadab, B. H., & Castillo, A. (2014). Bitcoin Financial Regulation: Securities,Derivatives, Prediction Markets, and Gambling. *Columbia Science and Technology Law Review, XVI* .

Buchholz, M., Delaney, J., & Warren, J. (2012). *Bits and Bets Information, Price Volatility, and Demand for Bitcoin.* http://www.bitcointrading.com/pdf/bitsandbets.pdf adresinden alındı

Chaum, D. (1983). Blind Signatures for Untraceable Payments. D. Chaum, R. Rivest, & A. Sherman içinde, *Advances in Cryptology* (s. pp 199-203).

Cheah, E.-T., & Fry, J. (2015, February). Speculative bubbles in Bitcoin markets? An empirical investigation into the fundamental value of Bitcoin. *Economics Letters*(130), 32-36.

coinmarketcap.com. (2018, august 7). coinmarketcap.com: https://coinmarketcap.com/all/views/all/ adresinden alındı

(2018). *Electric Power Monthly*. Washington, DC: U.S. Energy Information Administration (EIA). 2018 tarihinde www.eia.gov adresinden alındı

Engle, R., & Granger, C. (1987). Co-integration and error correction: representation, estimation and testing. *Econometrica*, 251-276.

Evans, D. S. (2014, April 14). Economic Aspects of Bitcoin and Other. *University of Chicago Coase-Sandor Institute for Law & Economics Research Paper*(685).

Everaere, P., Simplot-Ryl, I., & Traoré, I. (2010). Double Spending Protection for E-Cash Based on Risk Management. *International Conference on Information Security*, (s. 394-408). Berlin.

Glaser, F., Zimmermann, K., Haferkorn, M., Weber, M. C., & Siering, M. (2014). BITCOIN - ASSET OR CURRENCY? *Twenty Second European Conference on Information Systems*,.

Goyal, S., van der Leij, M. J., & Moraga-González, J. L. (2006). An Emerging Small World. *Journal of Political Economy*, 403-412.

Granger, C. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*, 424–438.

Gujarati, D. (2013). *Basic Econometrics.* Mc Graw-Hill International.

Hayes, A. (2015). Cryptocurrency Value Formation: An Empirical Analysis Leading to a Cost of Production Model for Valuing Bitcoin. *Mediterranean Conference on Information Systems (MCIS).* http://aisel.aisnet.org/mcis2015/4 adresinden alındı

Johansen, S. (1988). Statistical Analysis of Co-integration Vectors. *Journal of Economic Dynamics and Control*.

Johansen, S., & Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Co-Integration with Application to the Demand for Money. *Oxford Bulletin of Economics Statistics*, 169–209.

Karlstrøm, H. (2014, January 21). Do libertarians dream of electric coins? The material embeddedness of Bitcoin. *Journal of Social Theory, 15*(1), 23-36.

Katsiampa, P. (2017, June 20). Volatility estimation for Bitcoin: A comparison of GARCH models. *Economics Letters*(158), 3–6.

Kauffman, R. J., & Walden, E. A. (2001). Economics and Electronic Commerce: Survey and Directions for Research. *International Journal of Electronic Commerce, 5*(4), 5-116.

LLC, H. S. (Dü.). (2011-2018). *www.bitcoinmining.com/bitcoin-mining-hardware/.* (Hesiod Services LLC) www.bitcoinmining.com. adresinden alındı

LLC, O. D. (Dü.). (2018). *http://www.in2013dollars.com/Internet-services-and-electronic-information-providers/price-inflation*. (Official Data Foundation / Alioth LLC) http://www.in2013dollars.com. adresinden alındı

Nakamoto, S. (2008, november 1). *Bitcoin: A Peer-to-Peer Electronic Cash System*. april 3, 2018 tarihinde bitcoin.org: https://bitcoin.org/bitcoin.pdf adresinden alındı

Narayan, P. (1979–1990). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics*.

Pesaran, M., Shin, Y., & Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 289–326.

Piotrowicz, W., & Cuthbertson, R. (2014, December 6). Introduction to the Special Issue Information Technology in Retail: Toward Omnichannel Retailing. *International Journal of Electronic Commerce, 18*(4), 5-16.

Rogojanu, A., & Badea, L. (2014, January). The issue of competing currencies. Case study - Bitcoin. *Theoretical & Applied Economics, 21*(1), s. p103-114.

Sapienza, P., & Zingales, L. (2012, June). A Trust Crisis. *International Review of Finance, 12*(2), 123-131.

Weber, B. (2016, December 22). Bitcoin and the legitimacy crisis of money. *Cambridge Journal of Economics, 40*(1), 17–41.

www.blockchain.com/charts/difficulty. (2017). (BLOCKCHAIN LUXEMBOURG S.A) www.blockchain.com. adresinden alındı

www.blockchain.com/charts/hash-rate. (2017). (BLOCKCHAIN LUXEMBOURG S.A.) 2018 tarihinde www.blockchain.com. adresinden alındı

www.btcsatoshi.com. (2018, April). www.btcsatoshi.com. adresinden alındı

Yermack, D. (2013, December). Is Bitcoin a Real Currency? An economic appraisal. *National Bureau of Economic Research*(19747).

Zähres, M. (2012). *E-money Niche market that might be expanding.* Frankfurt: Deutsche Bank AG. 2018 tarihinde alındı

APPENDIX

YEAR	NUMBER OF BITCOINS MINED	PRICE OF BITCOINS MINED	TOTAL COST	PROFIT DAILY SALES
2009	46.13836385	0	9374.24368	-9374.24368
2010	31.0945274	2.059750505	9400.379398	-9398.319647
2011	28.57882388	165.9789742	9416.99819	-9251.019216
2012	25.84617659	207.1148836	9433.433389	-9236.624927
2013	15.0645396	2885.761893	9478.316219	-6592.554326
2014	14.30162921	7620.068972	9558.11509	-1938.046118
2015	13.47965698	3693.621047	9529.66921	-5836.048163
2016	10.33817214	5500.989565	9542.282296	-4051.629531
2017	6.885707324	27386.21353	9787.400135	17598.8134
2018	1.111326714	12630.97323	1611.85557	11019.11766

Table 1: Profit Through Daily BITCOIN Sales

YEAR	BITCOIN PRICE DEC 31	NUMBER OF BITCOINS MINED	PRICE OF BITCOINS MINED	TOTAL COST	PROFIT YEARLY SALES
2009	0	46.13836385	0	9374.24368	-9374.24368
2010	0.3	31.0945274	9.328358219	9400.379398	-9391.051039
2011	4.22	28.57882388	120.6026368	9416.99819	-9296.395553
2012	13.41	25.84617659	346.5972281	9433.433389	-9086.836161
2013	757.71	15.0645396	11414.5523	9478.316219	1936.236081
2014	309.81	14.30162921	4430.787746	9558.11509	-5127.327343
2015	428.74	13.47965698	5779.268134	9529.66921	-3750.401076
2016	959.17	10.33817214	9916.064574	9542.282296	373.7822783
2017	12618.55	6.885707324	86887.64216	9787.400135	77100.24202
2018	9589.72	1.111326714	10657.31202	1611.85557	9045.456448

Table 2: Profit Through End of the Year Sales

Descriptive Statistics

	LNMP	LNFC	LNVC	LNPF
Mean	4.509	1.210	1.131	-3.288
Median	5.519	1.212	1.149	-2.383
Maximum	9.862	1.220	1.179	1.422
Minimum	-2.996	1.194	1.067	-10.127
Std. Dev.	2.904	0.006	0.036	2.466
Skewness	-0.709	-0.083	-0.276	-0.839
Kurtosis	2.844	2.441	1.696	3.175
Jarque-Bera	235.838	39.468	232.528	330.114
Probability	0	0	0	0
Sum	12538.47	3365.892	3144.124	-9143.05
Sum Sq. Dev.	23439.31	0.105047	3.5454	16901.33
Observations	2781	2781	2781	2781

Note: Descriptive statistics of all the variables represented in logarithmic form; MP represents the represents the market price of bitcoin; FC represents the fixed cost; VC represents the variable cost; finally, PF represents the pooling fee.

Table 3: Descriptive Statistics

Unit Root Tests

	Levels			First Difference		
Variables	ADF	PP	DF-GLS	ADF	PP	DF-GLS
lnMP						
τ_T	-2.481	-2.55	-0.823	-20.818***	-44.934***	-2.082
τ_μ	-2.262	-2.407	2.407	-20.768***	-44.968***	-0.303
τ	1.706	1.732	-	-20.431***	-44.924***	-
lnFC						
τ_T	-0.373	-0.371	-0.745	-57.760***	-57.760***	-57.753***
τ_μ	-0.829	-0.831	-0.995	-57.720***	-57.720***	-57.723***
τ	-0.556	-0.556	-	-57.723***	-57.723***	-
lnVC						
τ_T	-2.834	-2.837	-2.267	-57.786***	-57.786***	-57.785***
τ_μ	-0.561	-0.56	1.374	-57.794***	-57.794***	-57.725***
τ	2.122	2.126	-	-57.723***	-57.723***	-
lnPF						
τ_T	-2.801	-2.807	-1.007***	-53.793***	-53.771***	-2.227
τ_μ	-2.393	-2.391	1.622	-53.785***	-53.766***	-0.317
τ	-3.526***	-3.510***	-	-53.678***	-53.655***	-

Note: τ_T represents the most general model with a intercept and trend; τ_μ is the model with a intercept and without trend. Optimum lag lengths are selected based on Schwartz Criterion. *** denotes rejection of the null hypothesis at the 1% level. ** denotes rejection of the null hypothesis between the 1% level and 5 % level. * denotes rejection of the null hypothesis between the 5 % level and 10 % level. Tests for unit roots have been carried out in E-VIEWS 8.0.

Table 4: Unit Root Test

Bound Test

	Without Determintic Trends			
p	F_iii	p-val F_iii*	t_iii	p-val t_iii*
1	4.377114	0.0044	-3.35917	0.0008
2	2.636655	0.0481	-2.58421	0.0098
3	2.16808	0.0898	-2.24379	0.0249
4	2.309875	0.0744	-2.26381	0.0237

	With Determintic Trends					
p	F_iv	p-val F_iv*	F_v	p-val F_v*	t_v	p-val t_v*
1	5.738921	0.0001	7.270498	0.0001	-4.53368	0.0000
2	3.758454	0.0047	4.807101	0.0024	-3.63322	0.0003
3	3.36951	0.0093	4.256197	0.0052	-3.33721	0.0009
4	3.544328	0.0068	4.434441	0.0041	-3.38476	0.0007

Table 5: Bound Test

Critical Values for ARDL Testing Approach

	0.10		0.05		0.01	
K = 4	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
F_{IV}	2.474	3.312	2.920	3.838	3.908	5.004
F_V	3.588	4.605	4.203	5.320	5.620	6.908
F_{III}	2.823	3.885	3.363	4.515	4.568	5.960
t_V	-3.13	-3.84	-3.41	-4.16	-3.96	-4.73
t_{III}	-2.57	-3.46	-2.86	-3.78	-3.43	-4.37

NOTES: (1) k is the number of regressors of dependent variable in ARDL testing approach. F ratio of the model with unlimited intercept and unlimited trend manifest by F_{IV}, F ratio of the model unlimited intercept and trend manifest by F_V, F ratio of the model only with unlimited intercept manifest by F_{III} . (2) t ratios denote by t_V and t_{III}.

Table 6: Critical Values for ARDL Testing Approach

Bound Test for Level Relationship

	With Deterministic Trend			With Deterministic Trend		Conclusion
	*Fi*V	*F*V	*t*V	*F*III	*t*III	H_0
p = 1*	5.739[c]	7.270[c]	-4.534[b]	4.377[b]	-3.359[b]	Reject
2	3.758[b]	4.807[b]	-3.633[b]	2.637[a]	-2.584[b]	
3	3.370[b]	4.256[b]	-3.337[b]	2.168[a]	-2.244[a]	
4	3.544[b]	4.434[b]	-3.385[b]	2.310[a]	-2.264[a]	

Notes: Akaike information criterion (AIC) and Schwartz criteria (SC) were used to select the number of lags required in the co-integration test. p shows lag levels and * denotes optimum lag selection in each model as suggested by both AIC and SC. *F*IV represents the *F*-statistic of the model with unrestricted intercept and restricted trend; FV represents the F-statistic of the model with unrestricted intercept and trend; and FIII represents the F-statistic of the model with unrestricted intercept and no trend. tV and tIII are the t-ratios for testing the null of no co-integration respectively with and without deterministic linear trend. [a]Indicates that the statistic lies below the lower bound; [b]that it falls within the lower and upper bound; [c]that it lies above the upper bound.

Table 7: Bound Test for Level Relationship

Level Equation with Constant

	Coefficient	Std. Error	t-Statistic	Prob.
LNFC	-21.879*	12.051	-1.816	0.070
LNVC	13.040***	4.583	2.845	0.005
LNPF	0.969***	0.066	14.631	0.000
C	19.677	14.883	1.322	0.186

Notes: [i]***Significant at 1% values, ** Significant at 5% values, * Significant at 10% values. [ii] MP represents the represents the market price of bitcoin; FC represents the fixed cost; VC represents the variable cost; finally, PF represents the pooling fee.

Table 8: Level Equation with Constant

Conditional Error Correction Models through the ARDL Approach

	Coefficient	Std. Error	t-Statistic	Prob.
ΔLNFC	-1.0318	1.9004	-0.54296	0.5872
ΔLNVC	0.0445	0.7309	0.06094	0.9514
ΔLNPF	0.44726***	0.0093	47.7041	0.0000
C	3.53E-06	0.0010	0.0035	0.9972
ECT(-1)	-0.0108***	0.0027	-3.8879	0.0001
R-squared	0.450811	Mean dependent var		0.004376
Adjusted R-squared	0.450019	S.D. dependent var		0.051847
S.E. of regression	0.03845	Akaike info criterion		-3.67711
Sum squared resid	4.102606	Schwarz criterion		-3.66644
Log likelihood	5116.182	Hannan-Quinn criter.		-3.67326
F-statistic	569.4754	Durbin-Watson stat		2.012628
Prob(F-statistic)	0			

Notes: [i]***Significant at 1% values, ** Significant at 5% values, * Significant at 10% values. [ii] MP represents the represents the market price of bitcoin; FC represents the fixed cost; VC represents the variable cost; finally, PF represents the pooling fee.

Table 9: Conditional Error Correction Models Through the ARDL Approach

Granger causality tests under block exogeneity approach

Y / X	LNFC	LNVC	LNPF	LNMP	ECM(t-1) -- t-stat
			Without Deterministic Trend		
LN FC	--	2.86E-05 (0.9957)	0.001114 (0.9734)	1.805856 (0.1791)	-0.70392 (0.48154)
LN VC	3.15E-07 (0.9996)	--	0.222485 (0.6372)	0.104769 (0.7462)	2.29384 (0.02187)
LN PF	0.255934 (0.6130)	0.728769 (0.3934)	--	106.2040**** (0.0000)	3.23011*** (0.00125)
LN MP	0.195938 (0.6581)	0.336473 (0.5619)	0.640848 (0.4235)	--	-0.16860 (0.86612)
			With Deterministic Trend		
LN FC	--	3.06E-06 (0.9986)	0.025427 (0.8733)	1.580047 (0.2089)	0.36670 (0.71387)
LN VC	0.000671 (0.9793)	--	0.122375 (0.7265)	0.061172 (0.8047)	1.00973 (0.31271)
LN PF	0.260876 (0.6096)	0.468545 (0.4937)	--	102.9593*** (0.0000)	4.34995*** (0.00001)
LN MP	0.195370 (0.6585)	0.344857 (0.5571)	0.628188 (0.4281)	--	-0.18595 (0.85249)

Notes: [i]***Significant at 1% values, ** Significant at 5% values, * Significant at 10% values.

Table 10: Granger Causality Tests Under Block Exogeneity Approach

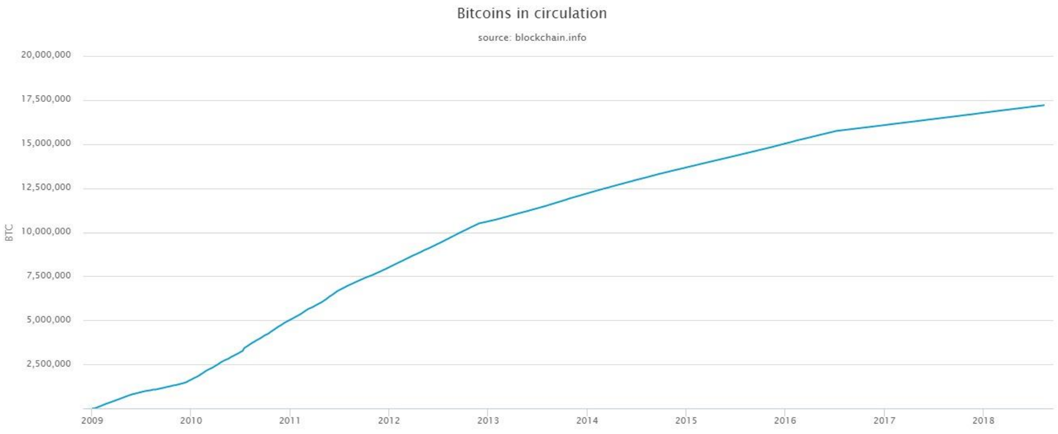

Figure 1: BITCOINS in Circulation

Figure 2: BITCOIN Market Price

Figure 3: BITCOIN QR-code

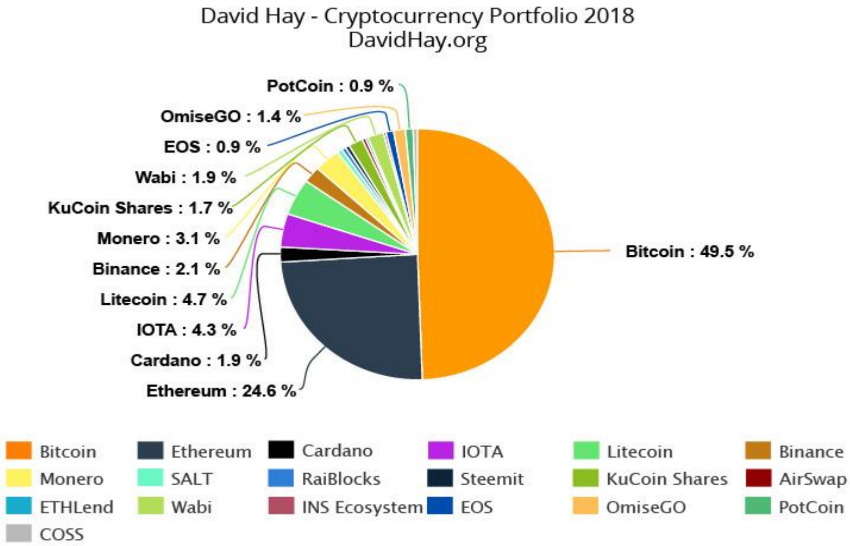

Figure 4: BITCOIN Market Share

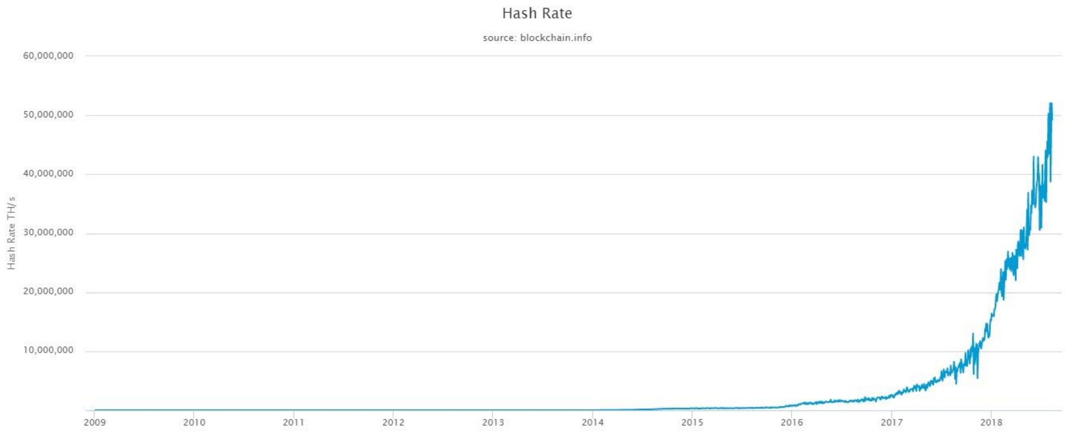

Figure 5: BITCOIN Hash-Rate

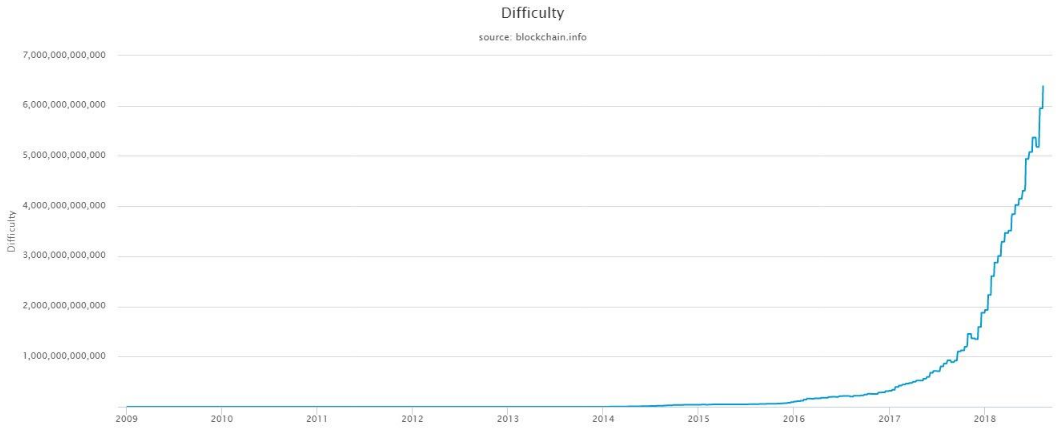

Figure 6: BITCOIN Difficulty

Figure 7: ASIC Mining System

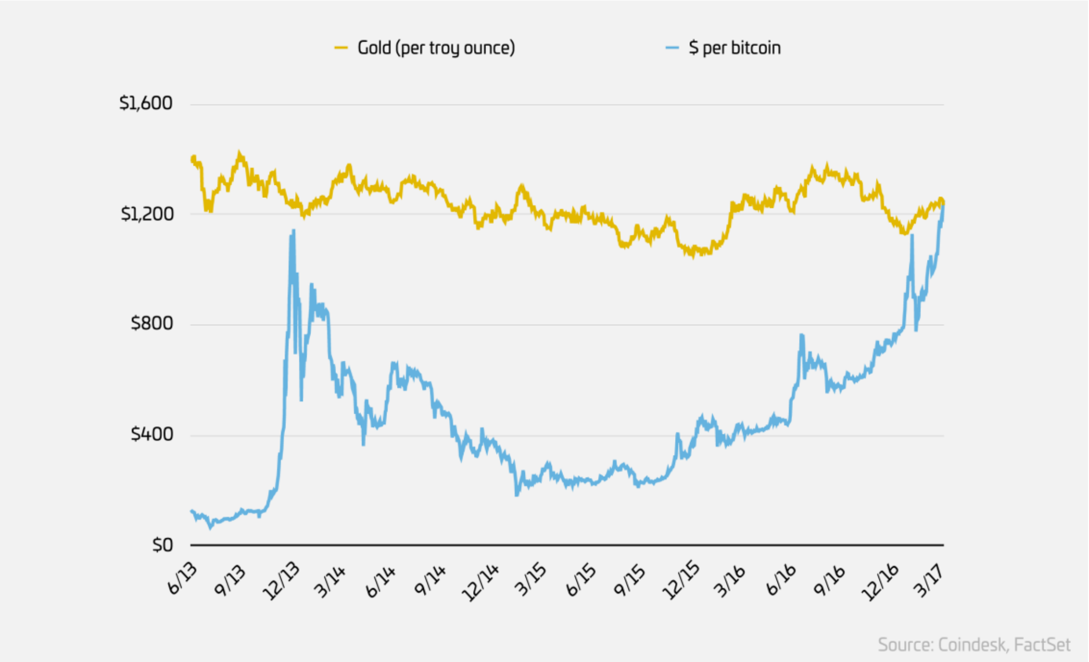

Figure 8: BITCOIN VS GOLD